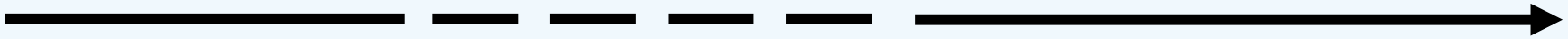
ESRL Global Model Research & Development for Weather and Climate Predictions

Dr. Jin-Luen Lee
March 9-12, 2010

Weather Forecast
(Initial Boundary Value Problem)

Climate Projection
(Forcing Problem)



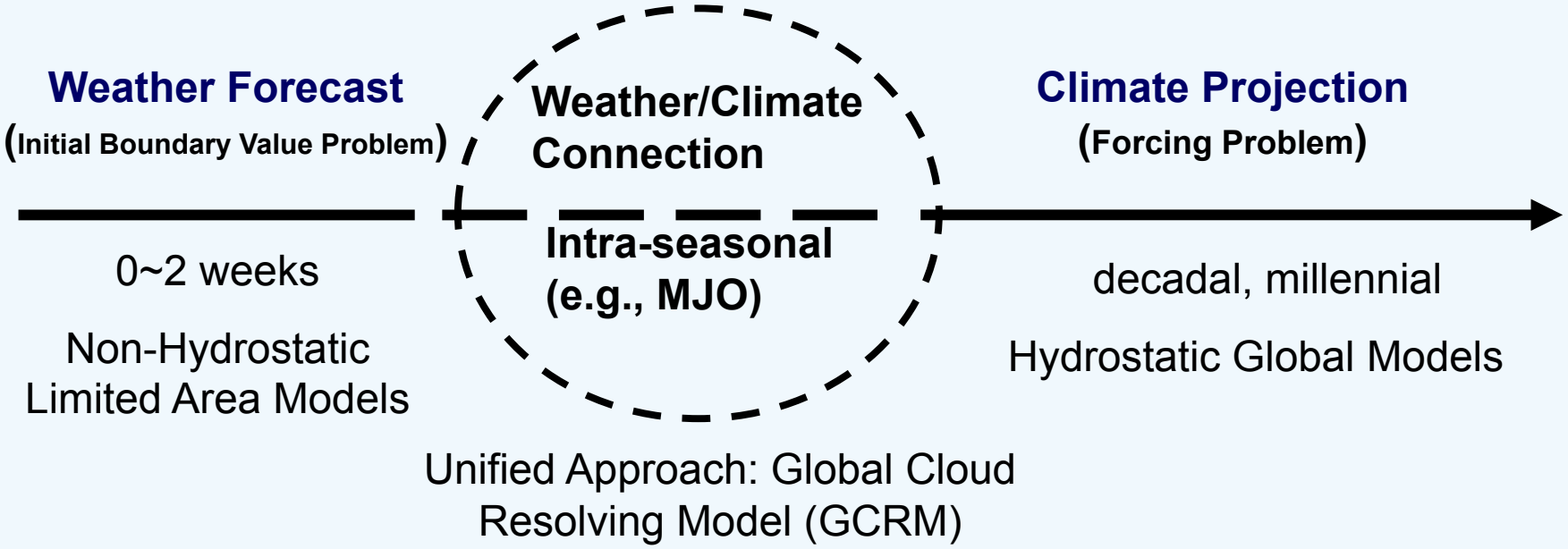
0~2 weeks

Non-Hydrostatic Limited Area Models

decadal, millennia

Hydrostatic Global Models

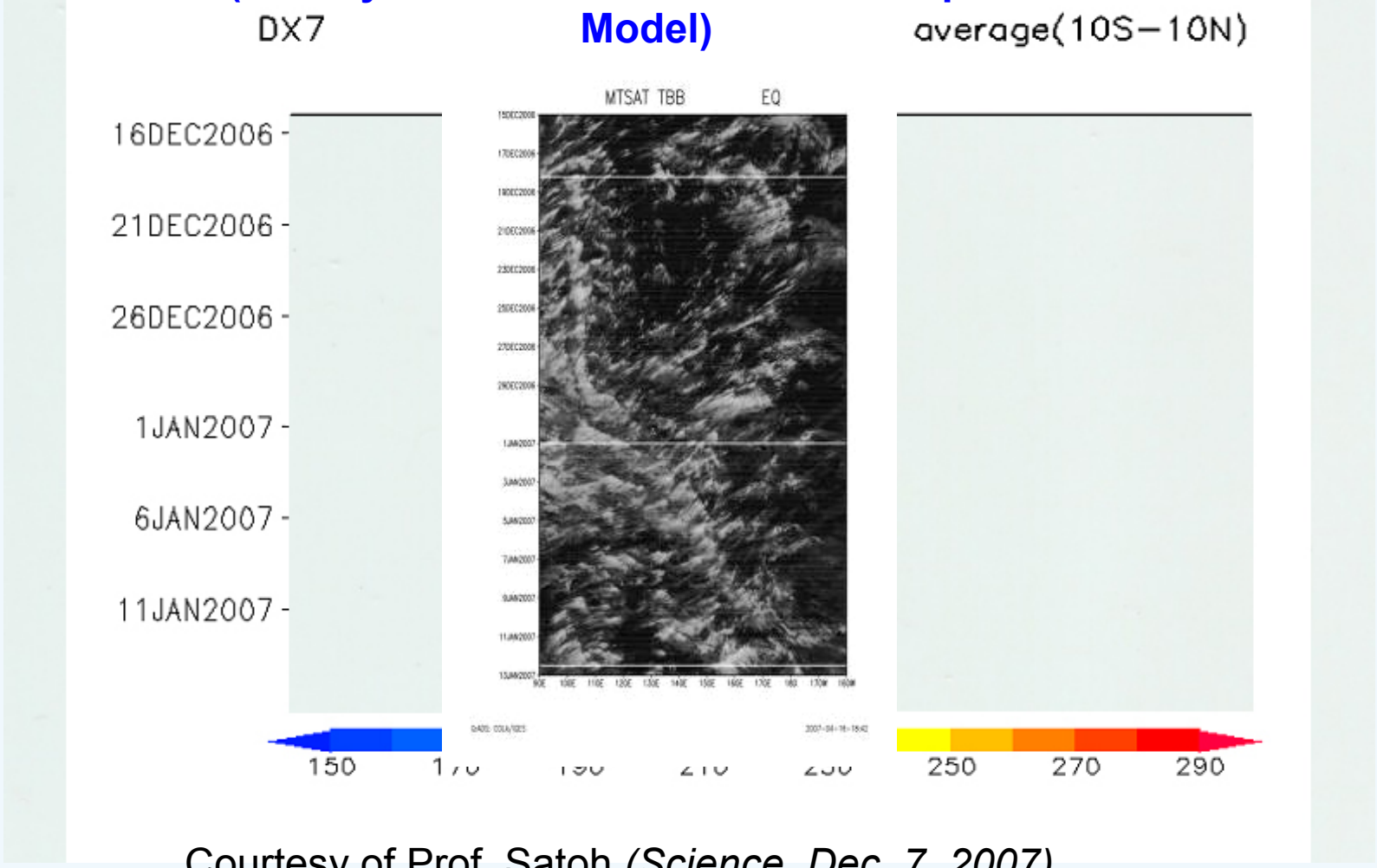
- **Lateral Boundary Limitation**
- **Inadequate GCM Cumulus Parameterizations**



- **GCRM to "Explicitly Resolve" Tropical Convective Cloud Systems**
- **Lateral Boundary Limitation**
- **Inadequate GCM Cumulus Parameterizations**

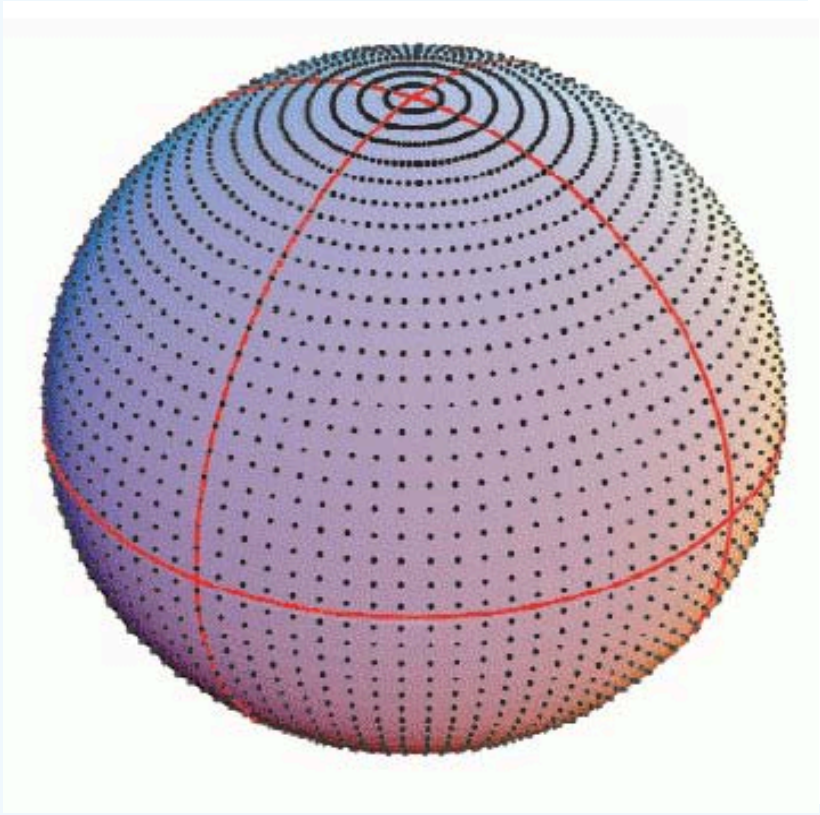
OLR Hovmoller Showing MJO Simulation

NICAM dx=3.5 km (Non-hydrostatic ICosahedral Atmospheric Model)

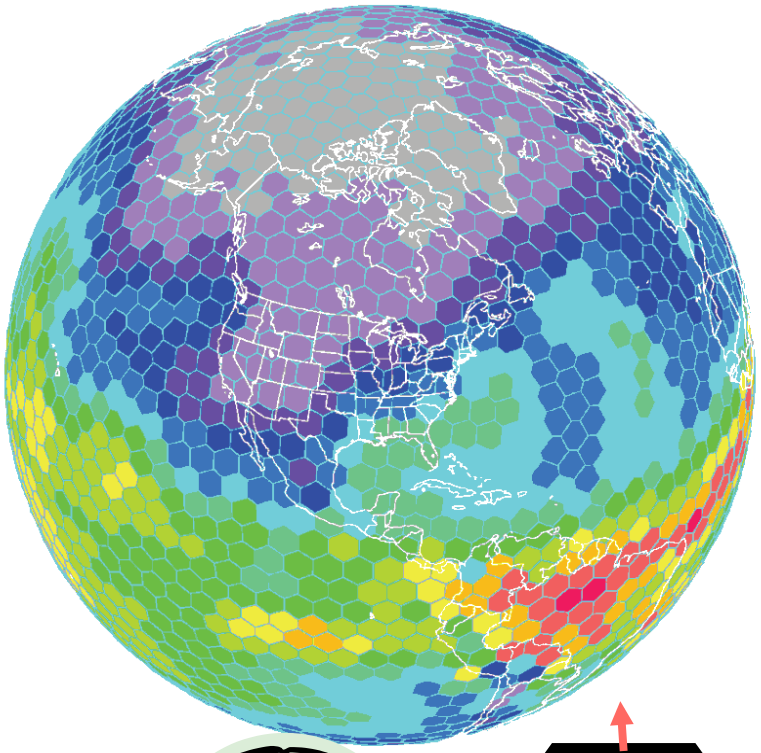


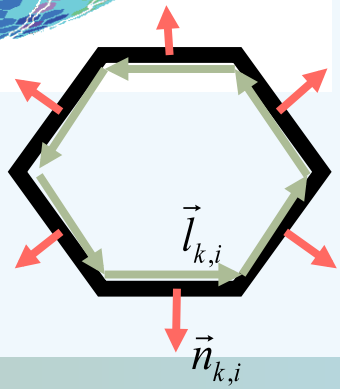
Courtesy of Prof. Satoh *(Science, Dec. 7, 2007)*

Lat/Lon Model



Icosahedral Model





- **Near constant resolution over the globe**
- **Efficient high resolution simulations**

ESRL Finite-volume Icosahedral Models

ESMF

1. FIM (Flow-following Finite-volume Icosahedral Model):

- a hydrostatic model for weather applications
- close collaboration with NCEP for global model ensembles as an ensemble member

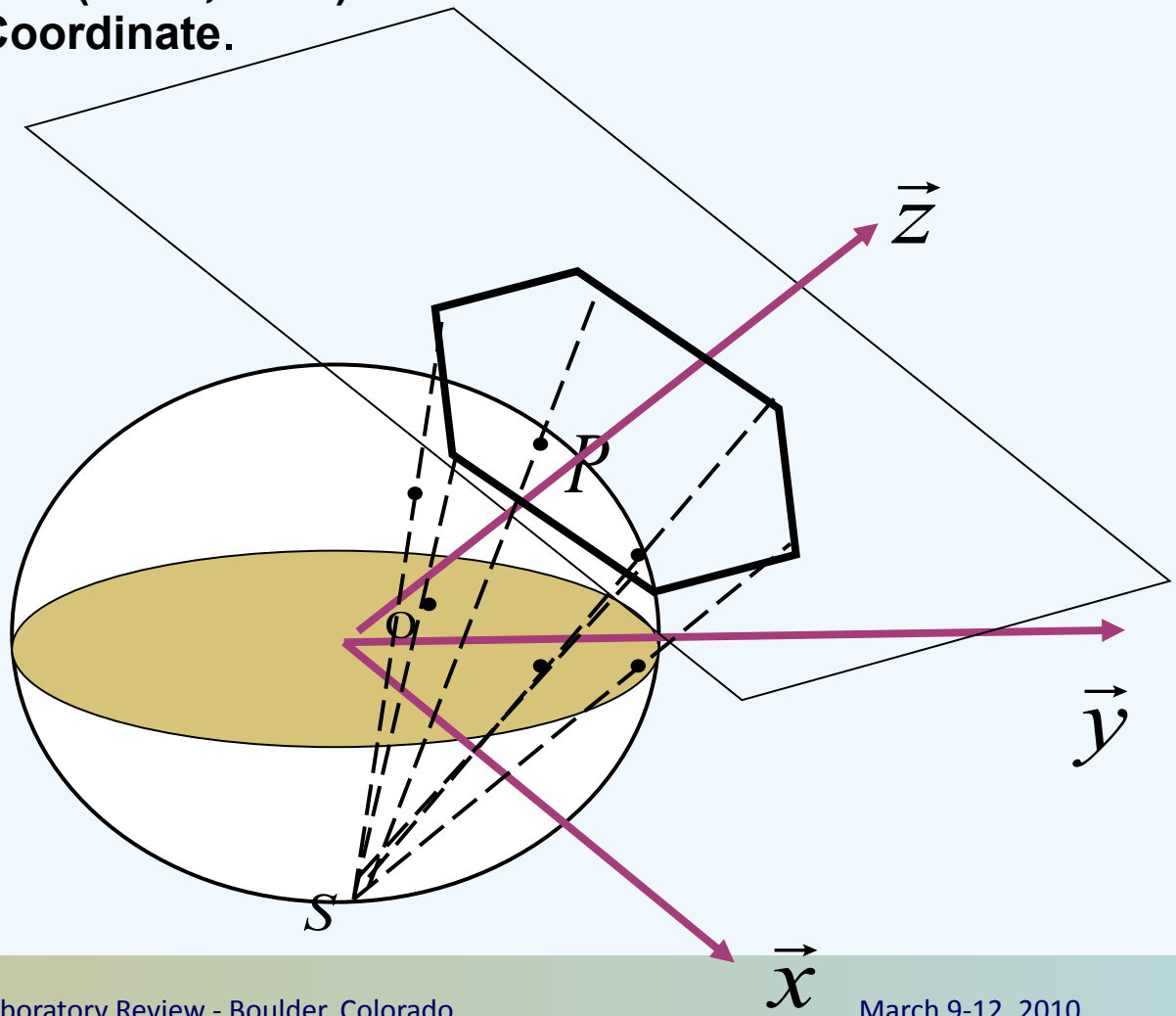
2. NIM (Non-hydrostatic Icosahedral Model):

- a non-hydrostatic global cloud resolving model for weather and climate applications
- collaboration with GFDL, CSU, NCAR, and others

Novel Features of FIM/NIM:

- **Finite-Volume Integrations on *Local Coordinate***

Lee and MacDonald (*MWR, 2009*): A Finite-volume Icosahedral Shallow Water Model on Local Coordinate.



Novel Features of FIM/NIM:

- **Finite-volume Integrations on *Local Coordinate***
- **Conservative and Monotonic Adams-Bashforth 3rd-order FCT Scheme**

- Lee, Bleck, and MacDonald (2010, JCP): A Multistep Flux-Corrected Transport Scheme (in review).

AB3-MFCT extends Zalesak's (1979) two-time level to multiple time levels.

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- **Efficient Indirect Addressing Scheme on Irregular Grid**

  - MacDonald, Middlecoff, Henderson, and Lee (2010, IJHPC) : A General Method for Modeling on Irregular Grids (in review).

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- **Grid Optimization for Efficiency and Accuracy**

  - Wang and Lee (2010, SIAM): Geometric Properties of Icosahedral-Hexagonal Grid

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- **FIM: Hybrid σ-θ Coordinate w/ GFS Physics**

  - Bleck, Benjamin, Lee and MacDonald (2010, MWR): On the Use of an Arbitrary Lagrangian-Eulerian Vertical Coordinate in Global Atmospheric Modeling (*in press*).

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  -Use of Three-dimensional Control Volume in Height Coordinate

  -3-D Volume Integration w/o Terrain Transformation Terms to Improve PGF Accuracy

  -An Explicit Riemann Solver to Resolve Vertically Propagating Acoustic Wave

  -Dynamical Design to Utilize Fast Graphic Processing Unit (GPU) to Speed up Calculations

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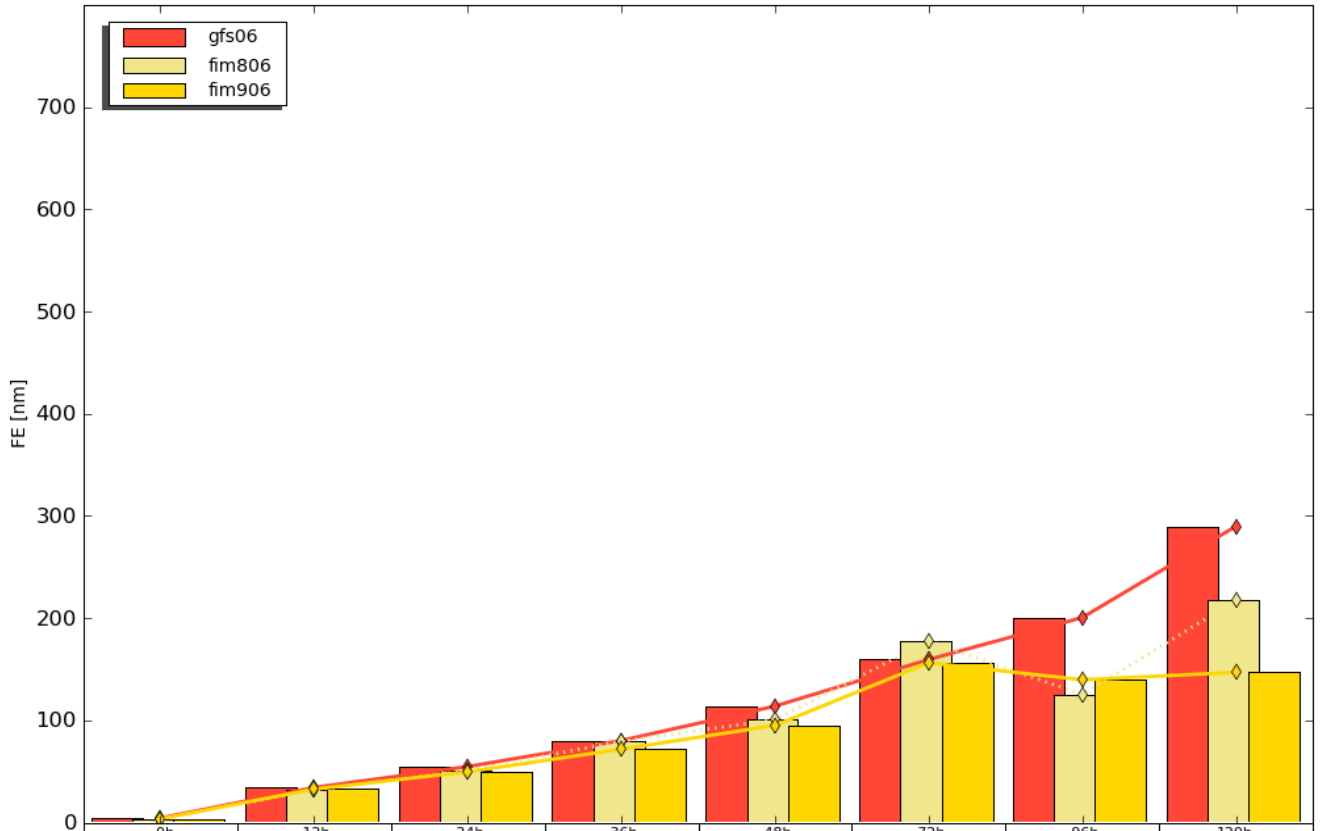
Research leads to operational technology transfer

- FIM Achieves Comparable Weather Forecast Scores as GFS
- FIM Successfully Improves Hurricane Forecasts

LANT 2008 gfs v fim8 v fim9 -- operational postprocess 6h interp

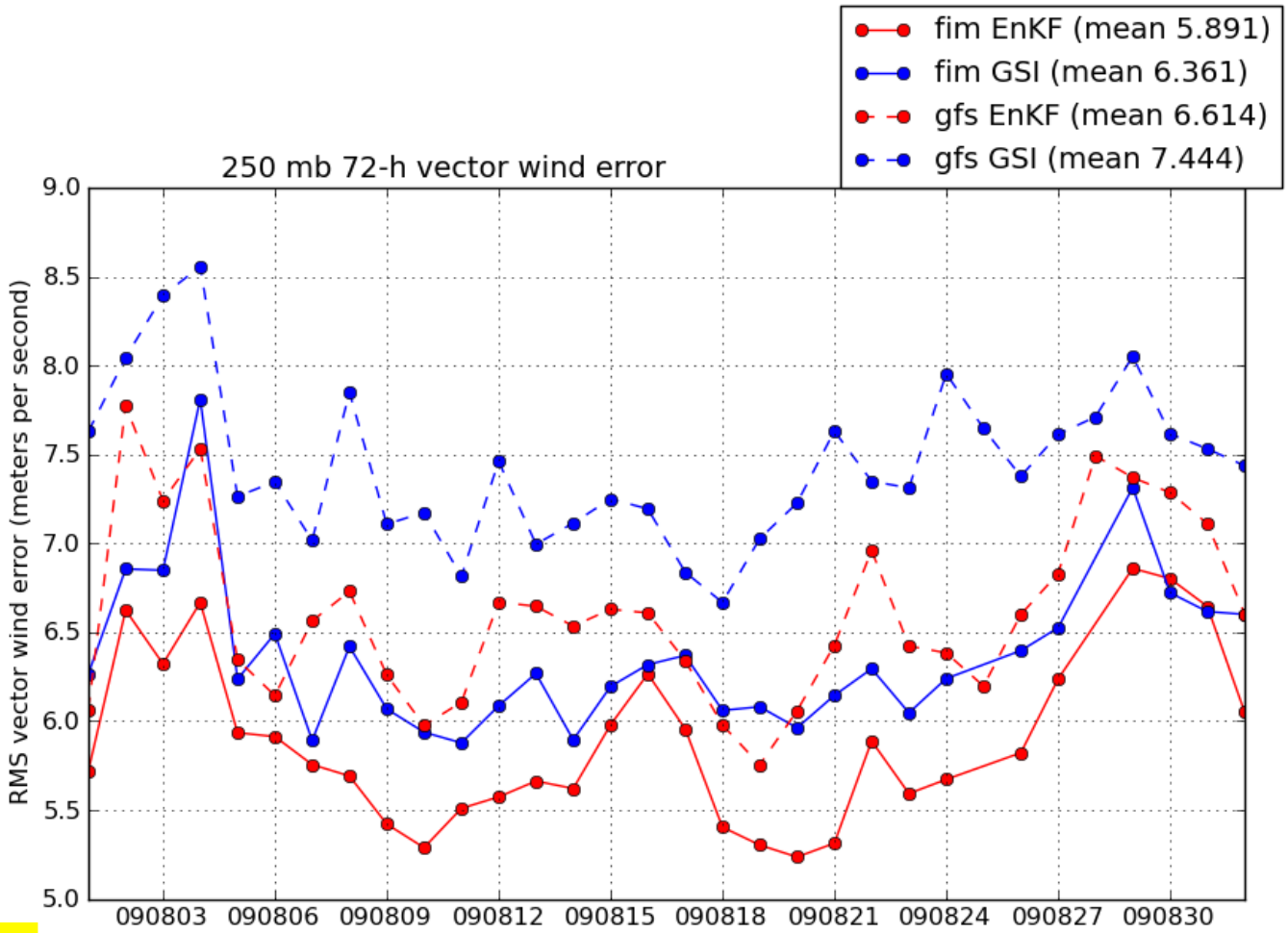
Models: gfs06 fim806 fim906

Storms[N] [9]: 08L.8 09L.8 10L.8 11L.8 12L.8 14L.8 15L.8 16L.8 17L.8



	0h	12h	24h	36h	48h	72h	96h	120h
gfs06	4[19]	34[17]	55[13]	80[12]	114[11]	159[8]	201[6]	290[5]
fim806	4[18]	32[17]	51[13]	79[12]	101[11]	177[8]	125[6]	217[5]
fim906	4[18]	33[17]	50[13]	72[12]	95[11]	156[8]	140[6]	147[5]

72-h **250-hPa** Wind RMS vector error (vs. analyses) **smaller is better**



FIM – ————
GFS ----------
GSI init conds
EnKF init conds

FIM **much** better than GFS
EnKF IC adds further accuracy

Final Remarks and Future Outlook

- **A hydrostatic Flow-following Icosahderal Finite-volume Model, FIM, has been developed, tested and prepared for operational NCEP global model ensemble systems.**

- **A Non-hydrostatic Icosahderal Finite-volume Model, NIM, has been developed and tested w/ meso-scale benchmarks.**

- **Future NIM applications for intra-seasonal predictions, and hurricane intensity forecasts.**

*Relevant to NOAA climate predictions and projections mission: Improving intra-seasonal and inter-annual climate forecasts.